amount to be paid for will be the actual number of (MBM) in the completed and accepted structure computed as follows: actual sizes of full sawn timber and nominal sizes of dressed timber will be used. The length used will be the nearest commercial (multiples of 2 feet) lengths from which the representative pieces can be cut; except for pieces less than 10 feet in length, the lengths used will be the nearest commercial lengths, not exceeding 24 feet, from which the pieces can be cut in multiples.

B. **Glued Laminated Stringers and Glued Laminated Deck Panels.** The unit of measure for Glued Laminated Stringers and Glued Laminated Deck Panels will be the number, "Each," of the size and length designated in the Contract.

C. **Treated Timber Structure and Untreated Timber Structure.** When the Proposal Form stipulates payment will be made for Treated Timber Structure and Untreated Timber Structure on a Lump Sum basis, all labor, materials, equipment, etc., except piling, necessary to complete the work shall be included in the Lump Sum bid. Piling will be measured and paid for as specified in Section 622.

618.05 BASIS OF PAYMENT.

Payment will be made at the Contract Unit Price as follows:

Pay Item	**Pay Unit**
Untreated Timber	MBM
Treated Timber	MBM
Glued Laminated Stringers	Each
Glued Laminated Deck Panels	Each
Treated Timber Structure	Lump Sum
Untreated Timber Structure	Lump Sum

This payment will be full compensation for all labor, equipment, and materials necessary to complete the work.

SECTION 622
PILING

622.01 DESCRIPTION.

This work consists of furnishing and driving piles, including test piles.

622.02 MATERIALS.

Material shall meet the following:

Item	Section
Untreated Timber Piling	840.02
Treated Timber Piling	840.02
Steel Piling	840.01 A
Steel-Encased Concrete Piling	840.01 B
Steel Sheet Piling	840.03 A
Corrugated Steel Sheet Piling	840.03 B
Creosote Preservative Treatment for Timber	846
Paint	852

622.03 CONSTRUCTION REQUIREMENTS.

A. **Test Piles.**

1. **General.** The Contractor shall furnish and drive test piles of the type, size, number, length, and at the location specified.

   Test piles shall be driven using the same type and size of hammer to be used to drive regular foundation piles to final bearing.

   Test piles shall not be driven until excavation to the elevation of the bottom of the footing has been completed, or a hole larger than the diameter of the pile is prebored down to the elevation of the bottom of the footing in which the pile is driven.

   Test piles shall be driven to a minimum of 125% of the design bearing load or as required for a load test.

   When a timber test pile is driven to Plan length and does not achieve 125% of design bearing load, the Engineer will determine if an additional, longer test pile is required.

   A follower to drive test piles shall not be used.

   The lengths and number of piling shown on the Plans are estimated for bidding purposes and the length of the pile to be furnished will be determined by the Engineer from the results of driving test piles.

2. **Pile Formulas.** The formulas shown shall be applied when computing the bearing value by pile penetration for all piles. Penetration measurements to determine pile bearing values shall not be made when pile heads are damaged by burring, corrugating, or crushing or immediately after fresh cushioning material has been inserted over the head of the pile. In the absence of load tests, the safe bearing value of piles shall be determined by the following formulas unless otherwise specified:

$$P = \frac{3.5\,WH}{S + 0.4} \times \frac{W + 0.2\,M}{W + M} \quad \text{. . . . . For gravity hammers}$$

$$P = \frac{3.5\,E}{S + 0.2} \times \frac{W + 0.2\,M}{W + M} \quad \text{. . . . . For double acting or single acting steam or air hammers and diesel hammers}$$

Where:

P = Safe bearing value, in pounds.
W = Weight of striking parts (ram), in pounds.
H = Height of free fall of ram, in feet.
M = Weight of parts being driven, in pounds. Includes pile weight, anvil (if any), driving cap, etc.
E = Energy per blow, in foot-pounds.
S = Average penetration of pile in inches per blow for last five blows for gravity hammer and the last ten blows for steam, air, or diesel hammer.

The preceding formulas are applicable only when:

a. The gravity hammer has a free fall.

b. The head of the pile is free from broomed or crushed fiber.

c. The penetration of the pile is at a reasonably uniform rate.

d. There is no noticeable bounce after the blow. When there is a noticeable bounce, twice the height of the bounce shall be deducted from "H" to determine the value of "H" in the formula.

The bearing value of timber piles, as determined from formulas, shall be considered effective only when they are less than the safe working stresses for the materials of which the piles are made. When water jets are used with the driving, the bearing value shall be determined by the formulas from the results of driving after the jets have been withdrawn.

B. **Pile Driving.** Piling shall not be driven unless the Engineer is present and was given at least 24 hours advance notice of any pile driving operations.

Pile shall not be driven within 80 feet of concrete which has cured less than 3 days, or a greater distance if determined necessary by the Engineer.

Before driving foundation piles, the excavation shall be completed to the bottom of the footing elevation.

Any excess excavation and voids remaining after pile driving is completed shall be backfilled and compacted to the bottom of the footing elevation with foundation fill, at the Contractor's expense.

Timber piles may be sharpened at the tip.

A steel head block or cap fitted to the pile head shall be used to prevent damage to the pile head. The head block or cap shall be provided with a shock block or cushion. Where necessary, bands shall be used to prevent splitting in the body of timber pile.

Pile driver leads shall be used for all types of hammers. They shall allow free movement of the hammer and rigidly hold the pile in correct alignment during the driving operation.

The driving of piling with followers is not permitted.

When specified penetration cannot be obtained without damaging the pile, the Engineer may approve the use of jetting, preboring, or spudding to secure the required penetration. The final driving shall be with the hammer for determining bearing.

When pilings are driven through a constructed embankment, having a thickness of 5 feet or more below the bottom of footing, the embankment shall be prebored for each pile. All pilot holes not completely filled by piles shall be backfilled with sand or fine gravel before the substructure is built.

Sawing or cutting the body of a pile to assist in springing it to proper location is not permitted. If a pile vibrates excessively or shows signs of buckling during driving, it shall be braced or guyed to assure satisfactory results.

Damaged piles shall be replaced or corrected.

Sections of piling that become part of the structure shall not be reduced in cross-section by drilling or burning holes for handling purposes. Any section of piling that is drilled or burned shall be removed and not incorporated into the structure.

During the driving of foundation piling, the pile shall not deviate from the vertical or from the specified batter more than 1/2 inch per foot of pile length. After driving, the center of the pile at the cutoff shall not be more than 6 inches from Plan location. Piling that are not driven to these tolerances will be rejected.

During driving, the piles for trestle bents shall not deviate from the vertical or from the specified batter more than 1/4 inch per foot of pile length. After driving, the piles shall support the cap in its proper position with full bearing on each pile. Piling that are not driven to these tolerances will be rejected.

Steel and precast concrete trestle piles shall be driven between guides rigidly held in position during the driving. The guides shall be securely braced to adjacent piling or to temporary piling.

Steel-encased concrete piles shall be driven using a steel combination driving head and pilot of the proper size to ensure properly distributed hammer blows on the pile shells to prevent damage. Clearance between the pilot ring and the pile shell shall not exceed 1/4 inch. A cushion block of timber shall be used between the hammer and the driving head. Dimensions of the pile shell shall be as specified on the Plans. The end enclosure plate shall be circular, not less than 3/4 inch in thickness, and not be larger in diameter than the outside diameter of the pile shell.

Adequate lighting shall be provided for inspection of the pile shell throughout its entire length. Improperly driven, broken, and defective pile that is not watertight, shows bends, kinks, or other deformations shall be removed and replaced or repaired by and at the Contractor’s expense. The tops of pile shells that are not filled with concrete immediately after driving shall be sealed temporarily to prevent the entrance of water or foreign substances.

All pile shells for any one bent, pier, or abutment shall be completely driven before any concrete is placed in the pile shells. If this is not practical, the remaining

pile shells shall not be driven until the concrete in all pile shells attains a compressive strength of 2,000 pounds psi.

The pile driving operations are not considered complete until all heaved piles have been redriven.

C. **Pile Hammers.**

1. **General.** The pile hammer shall meet the requirements of energy and ram weight as specified unless the Contractor can prove with a load test that piling driven with a smaller energy hammer holds, without failing, a load at least 2-1/2 times the specified bearing. This proof test load shall be at the Contractor's expense. If not specified, the minimum foot-pounds of energy per blow developed by steam, diesel, or air hammer shall not be less than 10,000 foot-pounds nor less than 2 times the weight of the pile in pounds, whichever is greater. A steam, diesel, or air hammer shall be operated at its rated number of blows per minute while determining bearing.

2. **Gravity Hammer.** The minimum weight of a gravity or "drop" hammer for driving steel or steel-encased concrete piles shall not be less than 4,000 pounds nor less than the combined weight of the pile and driving head, whichever is greater. The minimum weight of a gravity or "drop" hammer for driving all other piles shall not be less than 3,000 pounds nor less than the weight of the pile and driving head, whichever is the greater. The fall of the hammer shall be regulated to avoid damage to the pile and shall not exceed 15 feet for timber and steel piling, or 10 feet for steel-encased concrete piling.

3. **Diesel Hammer.** When using a diesel hammer, the maximum foot-pounds of energy per blow used in computing the driving bearing of individual piles shall be the manufacturer's rated energy with the following applicable reductions:

   a. When using open top type diesel hammers, a reduction in the rated energy shall be made if the hammer does not maintain the minimum measured stroke. This reduction shall be based on the percentage of the reduced stroke.

   b. When using a closed top type diesel hammer, the maximum energy shall be the rated energy subject to the condition that the Contractor shall furnish an appropriate readable gauge and chart to measure the bounce chamber pressure and resulting hammer output. If no instrument is provided, an independent testing firm shall be furnished to perform dynamic testing on the piling. The testing shall be at the Contractor's expense.

4. **Air Hammer.** When using an air (or steam) hammer, the maximum foot-pounds of energy per blow for computing the driving bearing of individual piles shall be the accepted manufacturer's energy rating subject to the following condition:

   When using double-acting air (or steam) hammers, the manufacturer's rated energy is applicable only when the required pressure (mean effective) is properly delivered to the hammer as specified by the manufac-

turer. When pressure at the hammer is below that specified, the energy shall be adjusted downward according to E = H(W + AP).

Where:

E = Energy per blow, in foot-pounds.
H = Height of fall, in feet.
W = Weight of striking parts (ram), in pounds.
A = Area of piston, in square inches.
P = Steam (or air) pressure at the hammer in pounds per square inch.

When the use of an air (or steam) hammer is proposed, the Engineer shall be furnished a descriptive catalog showing the essential Specifications necessary to determine hammer output.

D. **Bearing Value.** The design load of foundation piles in a substructure unit and the minimum penetration will be shown on the Plans.

Piling shall be driven to obtain the minimum penetration and design load, or to a penetration and bearing determined by the Engineer. Bearing value shall be determined by the formula specified which is applicable to the type of hammer used.

If the Engineer determines that it is necessary to drive piles through thin layers of hard material underlaid with soft material, the pile driving forces through the thin layers may exceed the anticipated driving forces needed to obtain the specified bearing.

E. **Cutoff and Treatment of Pile Heads.**

1. **Timber Piles.** The tops of all timber piling shall be cut off to the planes and elevations specified. Piles which support timber caps or sills shall be sawed to the plane of the superimposed structure. The head of the cutoff pile shall be sound, undamaged wood.

All cuts and abrasions in treated timber piles shall be given 3 applications of hot creosote oil and covered with roofing pitch. All holes bored in treated timber piles shall be given 2 applications of hot creosote before the bolts are placed.

The heads of treated timber piles which are imbedded in concrete shall be given 3 heavy applications of hot creosote oil and a thick layer of roofing pitch.

The heads of all cut off treated timber piles for trestle bents, wing piles, and foundation piles for timber bents shall receive the following treatment:

A ring of metal shall be provided near the edge of the top of the pile. One inch of creosote oil shall be placed inside the ring and on top of the pile for 36 hours to assure adequate penetration of the end fibers. The end of the pile shall be covered with a thick layer of roofing pitch. A circular cap of aluminum, not lighter than 25 U.S. gauge and not smaller than 6 inches larger than the diameter of the pile, shall be neatly bent and crimped around the sides of the pile. The lower edges of the aluminum

cap shall be covered with a strip of aluminum (at least 2 inches wide) of the same grade and thickness, using 2-inch aluminum nails for fastening.

2. **Steel Piling and Steel-Encased Concrete Piling.** Steel piles shall be cut off at the established elevation. When steel cap plates are specified, the cutoff shall be at 90° to the axis of the pile and shall be cut true to provide full bearing over the entire cross section of the pile.

   Final cutoffs shall be approximately 90° to the axis of the pile.

F. **Extensions.**

1. **Timber Piling.** Full length timber piles shall be used.

2. **Steel Piling and Steel-Encased Concrete Piling.** When it is necessary to increase the length of steel piles and steel-encased concrete piles, an additional length may be spliced to the original length. The sections shall be of identical cross-section. Steel piling and steel-encased concrete piling shall be spliced by welding according to Plan details.

   Splices shall provide and maintain true alignment and position of the component parts of the pile during and after installation. Field splices in steel pile shells shall develop the full strength of the shell and shall be watertight.

   The minimum lengths of pile which may be spliced by welding shall not be less than 5 feet. A shorter length may be used to make the last splice below cutoff.

   Steel piling sections spliced together by welding while in horizontal position shall not exceed the following variation in straightness in inches:

$$\frac{1/8 \text{ inch X number of feet of total length}}{10}$$

   Only qualified welders shall splice steel piling and steel-encased piling. For splices made with the pile in the horizontal position, the welder shall be qualified for position 3G (vertical groove) and 4F (overhead fillet). For splicing vertical reinforced concrete pile shells and vertical steel H-piling without reinforcing plates, the welder shall be qualified for position 2G (horizontal groove). For splicing vertical steel H-piling with reinforcing plates, the welder shall be qualified for position 2G (horizontal groove), 3F (vertical fillet), and 4F (overhead fillet). The cost of testing and certification shall be at the Contractor’s expense. Test welds shall be witnessed by a representative of either the Department or an independent testing agency.

   A copy of the welder’s qualification test certificate shall be subject to approval by the Engineer before the welder performs any welding. Approval will be for one year from the date of qualification. Approval of the welder’s certification may be requested for additional periods of one year, up to a maximum of 3 one-year extensions, if the welder has been actively engaged at welding in the required positions within the previous 6 months. The Department has the right to require a requalification test at any time.

Steel may be welded up to and including 3/4-inch thickness without the use of preheat when the base metal temperature is not lower than 50°F. If the base metal temperature is lower than 50°F., the base metal shall be heated to at least 50°F. and the temperature maintained during welding.

When the air temperature approaches 0°F., welding shall not be done until protection has been provided which keeps the air temperature surrounding the work above 0°F.

When preheating the base metal is required, it shall be performed so the surfaces of the parts on which metal is being deposited, within 3 inches of the point of welding both laterally and in advance of the welding, are at or above the 50°F. temperature specified. Base metal shall not be preheated to more than 400°F.

No welding shall be done in rain, snow, or sleet, or high wind without adequate protection.

Electrodes shall meet "Carbon Steel Covered Arc Welding Electrodes" AWS-A5.1, Classification E6010, E6011, or E7018.

Three certified copies of test reports shall be furnished of all pertinent required tests of AWS-A5.1 made on electrodes of the same class, size, and brand; and which were manufactured by the same process and with the same materials as the electrodes furnished. The tests may have been for process qualification or quality control and shall have been made within one year before manufacture of the electrodes furnished. Three copies of the manufacturer's certification shall be furnished that the process and material requirements were the same for manufacturing the tested electrodes and the furnished electrodes.

All electrodes while in the original unbroken package shall be stored in a warm, dry room or other weatherproof location. Open packages of electrodes shall be immediately stored in a holding oven at a temperature of at least 250°F. Electrodes that are removed from the container or holding oven for welding, shall not be exposed to the atmosphere for more than 4 hours without redrying for 2 hours at between 450°F. and 500°F. Electrodes shall not be redried more than once. Electrodes that have been wet shall not be used.

G. **Steel-Encased Concrete Piling.**

1. **Filling with Concrete.** Concrete shall not be placed in pile shells containing water or any foreign substance.

   The pile shall be filled with Class AE Concrete meeting Section 802. The concrete shall be deposited in one continuous operation and the rate of depositing shall be moderated to avoid formation of air pockets.

   The concrete footing or cap shall not be placed until at least 2 hours after all piles within the pile group are filled with concrete.

2. **Reinforcement.** Reinforcement for the steel-encased piles shall be used if specified. Reinforcement shall be a rigidly tied cage. Reinforcement shall be

placed at a clear distance of one inch from the face of the pile shell, and shall be provided with spacers to ensure the specified clearance for the bars. Reinforcement shall meet Section 612. Concrete shall be placed in the shell to a point approximately 2 feet below the bottom elevation of the reinforcing steel assembly before placing the reinforcing steel assembly in the pile shell.

H. **Painting.** Parts of steel piles and steel-encased concrete piles exposed to view in the finished structure shall be painted according to Section 630.03 D.3. Portions of those piles extending above a level of 3 feet below the final ground surface elevation shall be painted. Galvanized piling may be used in lieu of painting.

622.04 STEEL AND CORRUGATED STEEL SHEET PILES.

The sheet piles shall be driven with a hammer of sufficient weight and driving capacity to overcome the inertia of the pile and the resistance of the soil, without peening or upsetting the pile ends. A driving cap made expressly for the type of sheeting being driven shall be used.

Any sheet pile broken because of defects or improper driving, driven out of proper position, or driven below Plan cutoff shall be removed and replaced at the Contractor's expense.

Damaged galvanized sheet piling surfaces shall be repaired by applying a paste of approved zinc powder and flux with a minimum amount of water. The surface to be coated shall be heated sufficiently with a torch so all metallics in the paste are melted when applied. Repair shall be at the Contractor's expense.

622.05 METHOD OF MEASUREMENT.

A. **Timber, Steel, and Steel-Encased Piling.** The footage of Timber, Steel, and Steel-Encased Piles to be paid for will be the actual number of Linear Feet of piling left in place in the completed work as accepted by the Engineer. Concrete and reinforcing steel used in Steel-Encased Concrete Piling will not be measured as separate items. All cutoffs become the Contractor's property.

B. **Test Piles.** Test Piles will be measured either by the number of Test Piles actually furnished, driven, and accepted by the Engineer; or by the number of Linear Feet of Test Pile specified, even if a lesser footage is actually furnished, driven and accepted by the Engineer. The Plans will indicate which type of measurement is to be used. Piling measured for as Test Pile will not be included in the measurement of pay footage of Piling. All cutoffs become the Contractor's property.

C. **Corrugated Steel and Steel Sheet Piling.** The unit of measure for Corrugated Steel and Steel Sheet Piling will be the "Square Foot," and the quantity to be paid for will be the number of Square Feet of piling actually remaining in the completed structure and accepted. The area in square feet will be obtained by multiplying the nominal width (distance center to center of joint) by the total length of the Sheet Piles remaining in place after the cutoff.

D. **Steel Pile Splices.** The unit of measure for Steel Pile Splices will be one pile splice which includes labor, equipment, materials, preparation of weld surfaces, and welding necessary to complete the splice. The quantity to be measured will be the number of pile splices determined as follows:

Steel Pile Splices located within the pile length called for or the length determined by the Engineer will not be measured. If a Test Pile is not required, the number of splices to be measured for payment will be those located at or beyond the length specified necessary to increase the length of a pile incorporated into the structure over the length specified. If a Test Pile is required, the number of splices to be measured for payment will be those located at or beyond the length determined by the Engineer necessary to increase the length determined by the Engineer. Steel Pile Splices required to increase the lengths of Test Piles over the lengths shown on the Plans and located at or beyond the lengths shown on the Plans will be measured for payment.

622.06 BASIS OF PAYMENT.

A. The linear feet or square feet of piling for each type of pile provided will be paid for at the Contract Unit Price except that the Unit Price for Timber Piling will be adjusted according to the following conditions:

When the Contractor is required to order individual Timber Pile lengths which are longer or shorter than the Plan length, the Contract Unit Price will be increased or decreased by the difference between the actual invoice cost of the piling ordered and the actual invoice cost of the Plan length piling.

No reduction in the Contract Unit Price will be made on piles shown to be 45 feet in length or less and ordered to a lesser length.

In all cases, the adjusted unit price will apply to the full length of pile remaining in place in the completed work and accepted by the Engineer.

Adjustment in Timber Piling prices will be made for each footing.

B. Test pile measured as stated will be paid for at the Contract Unit Price for each type of Test Pile.

C. When the final in-place quantity of each size of Steel or Steel-Encased Piling driven and accepted for payment varies from the original estimated quantity, the Contractor will be compensated for the difference in the two quantities as follows:

1. When the final piling quantity of each size underruns the Plan quantity by more than 25 feet, the Contractor will receive 20% of the Contract Unit Price for the entire difference in quantities. Payment for the in-place and accepted piling will be at Contract Unit Price.

2. When the final piling quantity of each size overruns the Plan quantity by more than 25 feet, the Contractor will receive the Contract Unit Price plus 10% for the excess over Plan quantity. Payment for Plan quantity of the in-place piling will be at Contract Unit Price.

3. No adjustment will be made when the final in-place quantity of piling for each size varies from the original estimated quantity by 25 lineal feet or less.

Provisions of Section 104.03 B.2 will not be applied to piling quantities.

If it becomes necessary to drive Timber Piles of greater length than is shown, the additional length driven will be paid according to Section 104.03 D.

When it is necessary to drive Steel Test Piles or Steel-Encased Test Piles of greater length than that shown, the additional length driven will be paid for at the Contract Unit Price per foot for “Steel-Encased Concrete Piling” or “Steel Piling.”

D. Pile Cutoff is defined as the difference between the measured length of the piling furnished, but not exceeding the length specified, and the length actually driven and incorporated in the structure.

1. Payment will be made for Pile Cutoff on Treated and Untreated Timber Piling under the following conditions:

   a. Cutoff used in the work as piling will not be paid for as cutoff.

   b. Payment for Pile Cutoff will be at the receipted invoice price delivered on the Project.

   c. All Pile Cutoff not used in the work as piling will remain the property of and shall be disposed of by the Contractor.

2. Payment will not be made for Pile Cutoff on Steel or Steel-Encased Concrete Piling.

E. The accepted quantity of Steel Pile Splices will be paid for by the following method for each pile splice:

1. Steel H-Pile. Four times the Contract Bid Price per foot of regular foundation piling of the same size spliced.

2. Steel-Encased Concrete Pile. Three times the Contract Bid Price per foot of regular foundation piling of the same size spliced.

SECTION 624
RAILINGS

624.01 DESCRIPTION.

This work consists of furnishing and installing metal railings for bridges, curbs, sidewalks, parapets, wingwalls, or retaining walls.

624.02 MATERIALS.

Materials shall meet the following:

Item	Section
Structural Steel	834.01
Miscellaneous Metals	834.02
Paint	852
Galvanizing	854
Ornamental Metal Railing	As shown on the Plans.

624.03 CONSTRUCTION REQUIREMENTS.

Steel fabrication and erection shall meet Section 616.